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Impact of High Density Planting and Weed Management Practices on Growth Parameters and Phenology of Bt Cotton

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A B S T R A C T

An experiment was conducted during kharif, 2015 at College farm, College of Agriculture, Rajendranagar, Hyderabad, comprised of four population densities 55,555 plants ha^{-1} (D_1), 1,11,111 plants ha^{-1} (D_2) normal planting, 1,11,111 plants ha^{-1} (D_3) paired row planting, 1,48,148 plants ha^{-1} (D_4) and weed management practices (pendimethalin 1.0 kg ha^{-1} as pre emergence fb pyrithiobac sodium 62.5 g ha-1+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60, DAS (W_1), pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha-1 at 15 DAS as early post emergence fb glyphosate ammomium salt 2.13 kg ha^{-1} at 45 DAS (W_2), pendimethalin 1.0 kg ha^{-1} as pre emergence fb HW at 20 and 45 DAS (W_3) and unweeded control (W_4) in randomized block design (factorial), replicated thrice. Among the plant densities, even though the plant density of 55,555 plants ha^{-1} showed more crop drymatter however, remaining three plant densities showed comparable yields. Among the weed management practices, pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS recorded more crop drymatter.

Introduction

India is the second largest producer of cotton in the world after China accounting for about 25.73 per cent of the world cotton production. In India, area under cotton is 105 lakh ha with production of 351 lakh bales and 568 kg ha^{-1} productivity Anonymous (2016-17).

In India, Maharashtra stands first in area of cotton followed by Gujarat and Telangana. Area in Telangana under cotton is 12.50 lakh ha with production of 48 lakh bales and productivity 653 kg ha^{-1} Anonymous (2016-17).

Sustain the cotton productivity in rainfed soils need to practice high density planting systems, with narrow and ultra-narrow spacing. Weed competition is severe during its initial growth stage. Venugopalan *et al.*, (2009) reported a reduction in yield due to weeds in cotton crop to the extent of 50 to 85 per cent. Jain (1982) reported that, weeds removed as high as 48-50 kg N, 8-15 kg P and 48-50 kg K ha^{-1}. Thus, if proper weed control measures are followed, there would be greater availability of nutrients and moisture for the benefit of crop (Jalis and Shah, 1982).

In cotton First 60 DAS was the most critical period for crop-weed competition, mostly in *kharif* season due to incessant rains, hand weeding and inter-cultivation become difficult in cotton. Farmers were forced to use herbicides for weed control in cotton. Hence, there is a need for selection of herbicides to control emerging weeds during the crop growth period. So to attain a season long weed control, integration of chemical, mechanical and cultural methods holds a great promise in crop production. Hence, integrated weed management in cotton play important role in increasing crop production. Pre emergence herbicides at recommended doses are generally capable of controlling annual weeds upto a period of 30 days (Pawar *et al.,* 2000). Brar*et al.,* (1995) stated that pre emergence application of pendimethalin @ 1.5 kg ha^{-1} followed by one hoeing at 30 DAS was effective for the control of annual broad leaved and grassy weeds like *Trianthema portulacastrum* and *Eleusine indica*. The concentration of PRE emergence herbicide was decreased beyond 30 days after application, so which effect the increases the weed population. Due to regular monsoon rains farmers were unable to intercultivate which leads to increase the weeds population and compete with crop plants and finally reduce the seed cotton yield. Hence, there is a need to go for sequential application of PRE followed by POE herbicides to manage the late emerging weeds to eliminate weed competition throughout the critical period (Pawar *et al.,* 2000).

Materials and Methods

A field experiment was conducted during kharif, 2015 at College farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. The farm is geographically situated an altitude of 542.6 m above mean sea level on 18’ 50o N latitude and 77.53o E longitude). The soil of the experimental field was sandy loam in texture, low in available N (250 kg ha^{-1}), medium in phosphorus (21.68 kg P_2O_5 ha^{-1}) and high in potassium (685.6 kg K_2O ha^{-1}).

The experiment was conducted to test the impact of four planting densities 55,555 plants ha^{-1} (60 cm×30 cm), 1,11,111 plants ha^{-1} (60 cm× 15 cm) normal planting, 1,11,111 plants ha^{-1} (60 cm×15 cm) paired row planting, 1,48,148 plants ha^{-1} (45 cm×15 cm) and weed management practices viz., pendimethalin 1.0 kg ha^{-1} as pre emergence fb pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60, DAS (W_1), pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS as early post emergence fb glyphosate ammomium salt 2.13 kg ha^{-1} at 45 DAS (W_2), pendimethalin 1.0 kg ha^{-1} as pre emergence fb HW at 20 and 45 DAS (W_3) and unweeded control (W_4) on yield and quality of Bt cotton in randomized block design (factorial), replicated thrice. The crop was sown on 26th june. Other cultural operations and plant protections measures were followed as per the recommendations. During the crop period rainfall of 404.3 mm was received in 28 rainy days in 2015 as against the decennial average of 683.1 mm received in 35 rainy days for the corresponding period. Five plants were randomly selected in each plot and tagged to record the regular observations. Four pickings of seed cotton yield was taken from each treatment for recording final yield data.

Results and Discussion

Plant height (cm)

Effect of plant densities

Weed with 55,555 plants ha^{-1} (D_1) at all the growth stages except at 60 DAS, but at 30, 120 DAS and at final harvest stage did not differ significantly with other densities (Tables 1). However, at 60 DAS more plant

height was observed with 1, 11,111 plants ha^{-1} (D_2) normal planting and was significantly superior over 1,11,111 plants ha^{-1} (D_3) paired row and 1,48,148 plants ha^{-1} (D_4), but it was on par with 55,555 plants ha^{-1} (D_1). At 90 DAS more plant height was recorded with 55,555 Linear increase in plant height was observed up to the end of the crop growing season. Increased plant height was notice plants ha^{-1} (D_1) and on par plant height was observed with 1,48,148 plants ha^{-1} (D_4), in turn this was on par with 1,11,111 plants ha^{-1} (D_3) paired row, which in turn on par with 1,11,111 plants ha^{-1} (D_2) normal planting. Similar trend was observed at 120 DAS and final harvest stage even though they did not differ significantly.

The taller plants at higher plant density late in the season might be due to inter plant competition for nutrients and light. Further the availability of horizontal space for individual plant at closer spacing reduced, due to which intense inter plant competition for nutrient and light suppressed node appearance and plants grew taller in respect of vertical space (Wang *et al.*, 2011).

Effect of weed management practices

Weed management practices showed significant influence on plant height at all the stages. Increase in plant height was observed with early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) at all the stages except at 30 DAS, where pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) recorded more plant height and was significantly superior over all other weed management practices, in turn these were on par with each other. But, at 60 and 120 DAS significantly more plant height was noticed with W_2 and was superior over all other weed management practices, this was followed by pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) and pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3) treatments, in turn these showed on par plant height with each other.

However, at 90 DAS and at final harvest stage, early PoE application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) treatment did not differ with W_1 and W_3 treatments. At all the stages significantly the lowest plant height was recorded with unweeded control (W_4) treatment. The decreased plant height was might be due to more weed dry matter and weed density at all the growth stages. The increased plant height in W_2 due to reduced weed dry matter and weed density with reduced broad and narrow leaf weeds from 60 DAS might be due to directed spray of non-selective glyphosate ammonium salt at 45 DAS. Similar results were reported by Ali *et al.*, (2013).

Interaction effect

Plant densities and weed management practices did not show any significant influence on plant height at any crop growth stage of the Bt cotton.

Crop drymatter (g $plant^{-1}$)

Effect of plant densities

Plant densities and weed management practices did not exert any significant influence on crop drymatter at 30 DAS (Table 2). Significant increase in CDM was observed with plant density of 55,555 plants ha^{-1} (D_1)

and was on par with 1,11,111 plants ha^{-1} (D_2) normal planting, in turn this was on par with 1,11,111 plants ha^{-1} (D_3) paired row planting, at all the growth stages, again these were was on par with 1,48,148 plants ha^{-1} (D_4) at 60 DAS and at final harvest. However, at 90 DAS and 120 DAS 1,11,111 plants ha^{-1} (D_3) paired row planting poduced significantly more drymatter over 1,48,148 plants ha^{-1} (D4).

Drymatter $plant^{-1}$ was higher with wider spacing, this might be due to more canopy development under wider spacing (Devraj *et al.,* 2011). The marked improvements in growth and yield attributing character was brought due to the more availability of solar radiation and that helps to synthesis and partitioning of assimilates to individual plant under wider spacing, which ultimately translocates assimilates from source to sink that leads to significant increment in growth attributes in respect of weight and diameter of plant (Bhalerao *et al.,* 2010 and Dhillon *et al.,* 2006).

Effect of weed management practices

Increase in crop drymatter was observed with pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) at all the crop growth stages and was not differed significantly with pre emergence application of pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3) and were significantly superior over rest of the weed management practices except at 60 DAS, where W_3 treatment was on par with early PoE of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) at remaining stages. The remaining two treatments differed significantly with each other and the lowest crop drymatter was recorded with unweeded control (W_4) treatment at all the crop growth stages.

The observed more crop drymatter production of cotton in W_1, W_3 and W_2 treatments was due to higher accumulation of photosynthates in leaves, stem and reproductive parts due to increase in the uptake of nutrients (Hiremath *et al.,* 2013), thereby increase in the growth of components and it lead to the higher dry matter production $plant^{-1}$ due to less weed dry matter and density while it was lower in unweeded control treatment (W_4).

Interaction effect

Plant densities and weed management practices did not show any significant influence on crop dry matter of Bt cotton at all the crop growth stages.

Main stem nodes (no. $plant^{-1}$)

Effect of plant densities

The node number $plant^{-1}$ increased progressively up to the end of the crop growing season (Tables 3). Node number differed significantly during early stage of the crop growth only (30 DAS, 60 DAS and 90 DAS) and did not show any significant influence at later stage of crop growth (120 DAS and at final harvest).

More number of main stem nodes $plant^{-1}$ was noticed with plant density of 55,555 plants ha^{-1} (D_1) at all the crop growth stages and was on par with 1, 11,111 plants ha^{-1} (D_2) normal planting, in turn it was on par with 1, 11,111 plants ha^{-1} (D_3) paired row planting, again this was in turn on par with 1, 48,148 plants ha^{-1} (D_4) at 30 and 60 DAS. However, at 90 DAS plant density of 55,555 plants ha^{-1} (D_1) was on par with 1,11,111 plants ha^{-1} (D_3) paired row planting and 1,48,148 plants ha^{-1} (D_4). Similar trend was observed with 120 DAS and at final harvest even though they were not differed significantly.

Total numbers of nodes were higher for low plant density than higher density as the nodes per plant were inversely related to the plant densities (Seibert, 2006 and Stewart *et al.*, 2006). But from the present study at 90 DAS increase in plant height was observed as the plant density was increased from 1, 11,111 plants ha^{-1} to 1, 48,148 plants ha^{-1}due to inter plant competition within the row.

Effect of weed management practices

Significant increase in main stem node number was observed with early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1} quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS fb by directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) except at 30 DAS and was on par with pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) and pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3), at all the stages except at 60 DAS where W_1 in turn on par with W_3 and significantly superior over unweeded control (W_4) treatment. But, at 30 DAS more main stem node number was observed with pendimethalin 1.0 kg ha^{-1} fb PoE application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) and was on par with W_2 and W_3 treatments and were significantly superior over unweeded control (W_4) treatment.

In the present study, the increase in main stem node number in early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1} quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) was might be due to increased plant height as evidenced from the Table 1.

Interaction effect

Interaction effect of plant densities and weed management practices did not show any significant influence on main stem node number of Bt cotton at all the crop growth stages.

Monopodial branches (No. $plant^{-1}$)

Effect of plant densities

Gradual increase in number of monopodial branches $plant^{-1}$ was observed from 60 DAS to 120 DAS (Table 4). However, at 60 DAS plant density did not show any significant influence on number of monopodial branches $plant^{-1}$.

But, at 90 and 120 DAS more number of monopodia $plant^{-1}$ was observed with plant density of 55,555 plants ha^{-1} (D_1) and was on par with 1,11,111 plants ha^{-1} (D_2) normal planting and were significantly superior over 1,11,111 plants ha^{-1} (D_3) paired row and 1,48,148 plants ha^{-1}(D_4) at 120 DAS, but 90 DAS D_2 and D_3 were on par with each other and were significantly superior over 1,48,148 plants ha^{-1} (D_4) treatment.

Effect of weed management practices

Weed management practices showed significant influence on monopodia $plant^{-1}$ at all the stages. Significantly more monopodia $plant^{-1}$ were observed at 60 DAS with early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) and was on par with pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) and pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3).

Table.1 Plant height of Bt cotton under varied plant densities and Weed management practices *kharif*, 2015

Treatment	Plant height (cm)				
Plant densities (D)	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**
D_1-60 cm×30 cm (55,555)	18	51	92	112	125
D_2-60 cm×15 cm (1,11,111)	18	53	80	102	116
D_3-60 cm×15 cm (1,11,111 Paired row- 45 cm × 75 cm)	18	48	84	105	124
D_4-45 cm×15 cm (1,48,148)	18	44	87	110	122
S. Em±	0.4	1.0	2.0	2.6	3.2
CD (P=0.05)	NS	3.02	5.94	NS	NS
Weed Management Practices (W)					
W_1-Pendimethalin 30% EC 1.0 kg ha^{-1} as PE fb PoE pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 5% EC 50 g ha^{-1} at 20, 40, 60 DAS	20	53	89	109	125
W_2-Pyrithiobac sodium 10% EC 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS as early PoE fb glyphosate 71% SG 2.13 kg ha^{-1} at 45 DAS	17	58	94	124	130
W_3-Pendimethalin 1.0 kg ha^{-1} as PE fb HW at 20 and 45 DAS	18	52	94	109	129
W_4-Unweeded control	17	32	67	86	104
S. Em±	0.4	1.0	2.0	2.6	3.2
CD (P=0.05)	1.2	3.0	5.6	7.7	9.3
Interaction (D X W)					
S. Em±	0.8	2.0	4.1	5.3	6.4
CD (P=0.05)	NS	NS	NS	NS	NS

Table.2 Crop drymatter of Bt cotton under varied plant densities and Weed management practices *kharif*, 2015

Treatment	Crop Drymatter (g $plant^{-1}$)				
Plant densities (D)	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**
D_1-60 cm×30 cm (55,555)	3.45	27.54	69.20	76.99	106.50
D_2-60 cm×15 cm (1,11,111)	4.44	27.10	58.33	73.99	96.21
D_3-60 cm×15 cm (1,11,111 Paired row- 45 cm × 75 cm)	4.33	20.00	50.01	64.34	86.08
D_4-45 cm×15 cm (1,48,148)	4.25	19.3	33.22	54.18	84.67
S. Em±	0.47	2.52	4.97	3.34	3.58
CD (P=0.05)	NS	7.32	14.43	9.69	10.41
Weed Management Practices (W)					
W_1-Pendimethalin 30% EC 1.0 kg ha^{-1} as PE fb PoE pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 5% EC 50 g ha^{-1} at 20, 40, 60 DAS	3.88	29.79	69.27	82.29	114.79
W_2-Pyrithiobac sodium 10% EC 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS as early PoE fb glyphosate 71% SG 2.13 kg ha^{-1} at 45 DAS	5.08	25.50	51.25	70.97	99.167
W_3-Pendimethalin 1.0 kg ha^{-1} as PE fb HW at 20 and 45 DAS	3.83	28.46	58.33	75.81	105.75
W_4-Unweeded control	3.70	10.19	31.91	40.43	53.75
S. Em±	0.47	2.52	4.97	3.34	3.58
CD (P=0.05)	NS	7.32	14.43	9.69	10.41
Interaction (D X W)					
S. Em±	0.95	5.04	9.95	6.67	7.17
CD (P=0.05)	NS	NS	NS	NS	NS

Table.3 Main stem nodes of Bt cotton under varied plant densities and Weed management practices *kharif*, 2015

Treatment	Nodes (No. plant^{-1})				
Plant densities (D)	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**
D_1-60 cm×30 cm (55,555)	6.72	14.12	20.22	24.35	26.67
D_2-60 cm×15 cm (1,11,111)	6.37	14.23	17.15	23.08	25.17
D_3-60 cm×15 cm (1,11,111 Paired row- 45 cm × 75 cm)	6.22	13.78	18.30	23.27	25.27
D_4-45 cm×15 cm (1,48,148)	5.90	13.70	18.05	24.15	26.13
S. Em±	0.15	0.13	0.30	0.81	0.68
CD (P=0.05)	0.46	0.40	0.89	NS	NS
Weed Management Practices (W)					
W_1-Pendimethalin 30% EC 1.0 kg ha^{-1} as PE fb PoE pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 5% EC 50 g ha^{-1} at 20, 40, 60 DAS	6.63	15.05	19.73	25.20	27.22
W_2-Pyrithiobac sodium 10% EC 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS as early PoE fb glyphosate 71% SG 2.13 kg ha^{-1} at 45 DAS	6.58	15.38	20.20	26.43	28.47
W_3-Pendimethalin 1.0 kg ha^{-1} as PE fb HW at 20 and 45 DAS	6.25	14.95	19.90	24.67	26.52
W_4-Unweeded control	5.73	9.95	13.88	18.55	21.03
S. Em±	0.15	0.13	0.30	0.81	0.68
CD (P=0.05)	0.46	0.40	0.89	2.36	1.99
Interaction (D X W)					
S. Em±	0.31	0.27	0.61	1.631	1.376
CD (P=0.05)	NS	NS	NS	NS	NS

Table.4 Monopodial branches in Bt cotton under varied plant densities and Weed management practices *kharif*, 2015

Treatment	Monopodial branches (No. plant^{-1})		
Plant densities (D)	**60 DAS**	**90 DAS**	**120 DAS**
D_1-60 cm×30 cm (55,555)	0.92	1.87	2.43
D_2-60 cm×15 cm (1,11,111)	0.88	1.83	2.35
D_3-60 cm×15 cm (1,11,111 Paired row- 45 cm × 75 cm)	0.83	1.62	2.12
D_4-45 cm×15 cm (1,48,148)	0.82	1.45	1.83
S. Em±	0.04	0.06	0.05
CD (P=0.05)	NS	0.19	0.16
Weed Management Practices (W)			
W_1-Pendimethalin 30% EC 1.0 kg ha^{-1} as PE fb PoE pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 5% EC 50 g ha^{-1} at 20, 40, 60 DAS	1.15	2.03	2.50
W_2-Pyrithiobac sodium 10% EC 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS as early PoE fb glyphosate 71% SG 2.13 kg ha^{-1} at 45 DAS	1.17	1.87	2.37
W_3-Pendimethalin 1.0 kg ha^{-1} as PE fb HW at 20 and 45 DAS	1.13	1.87	2.38
W_4-Unweeded control	0.00	1.00	1.48
S. Em±	0.04	0.06	0.05
CD (P=0.05)	0.11	0.19	0.16
Interaction (D X W)			
S. Em±	0.08	0.13	0.11
CD (P=0.05)	NS	NS	0.33

Table.4a Interaction effect of plant densities and weed management practices on monopodial Branches in Bt cotton *kharif*, 2015

Plant densities	Weed management practices				
	W_1	W_2	W_3	W_4	Mean
D_1	2.87	2.73	2.60	1.53	2.43
D_2	2.60	2.67	2.67	1.47	2.35
D_3	2.33	2.27	2.47	1.40	2.12
D_4	2.20	1.80	1.80	1.53	1.83
Mean	2.50	2.37	2.38	1.48	
S. Em±	0.11				
CD (P=0.05)	0.33				

Table.5 Height to node ratio in Bt cotton under varied plant densities and Weed management practices *kharif*, 2015

Treatment	Height to node ratio				
Plant densities (D)	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**
D_1-60 cm×30 cm (55,555)	2.64	3.56	4.55	4.60	4.71
D_2-60 cm×15 cm (1,11,111)	2.89	3.71	4.71	4.47	4.64
D_3-60 cm×15 cm (1,11,111 Paired row- 45 cm × 75 cm)	2.91	3.41	4.60	4.55	4.97
D_4-45 cm×15 cm (1,48,148)	3.06	3.22	4.88	4.64	4.74
S. Em±	0.06	0.05	0.11	0.14	0.16
CD (P=0.05)	0.18	0.16	NS	NS	NS
Weed Management Practices (W)					
W_1-Pendimethalin 30% EC 1.0 kg ha^{-1} as PE fb PoE pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 5% EC 50 g ha^{-1} at 20, 40, 60 DAS	3.02	3.51	4.54	4.34	4.64
W_2-Pyrithiobac sodium 10% EC 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS as early PoE fb glyphosate 71% SG 2.13 kg ha^{-1} at 45 DAS	2.65	3.79	4.66	4.68	4.56
W_3-Pendimethalin 1.0 kg ha^{-1} as PE fb HW at 20 and 45 DAS	2.84	3.50	4.72	4.55	4.90
W_4-Unweeded control	3.01	3.10	4.83	4.68	4.95
S. Em±	0.06	0.05	0.11	0.14	0.16
CD (P=0.05)	0.18	0.16	NS	NS	NS
Interaction (D X W)					
S. Em±	0.13	0.11	0.23	0.29	0.32
CD (P=0.05)	NS	0.32	NS	NS	NS

Table.6 Chlorophyll content (SPAD reading) in Bt cotton under varied plant densities and Weed management practices *kharif*, 2015

Treatment	SPAD reading			
Plant densities (D)	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**
D_1-60 cm×30 cm (55,555)	32.61	32.60	38.24	41.43
D_2-60 cm×15 cm (1,11,111)	32.10	32.10	35.03	40.66
D_3-60 cm×15 cm (1,11,111 Paired row- 45 cm × 75 cm)	32.04	32.04	35.94	42.43
D_4-45 cm×15 cm (1,48,148)	32.42	32.42	35.77	41.54
S. Em±	0.98	1.02	0.44	0.76
CD (P=0.05)	NS	NS	1.27	NS
Weed management practices (W)				
W_1-Pendimethalin 30% EC 1.0 kg ha^{-1} as PE fb PoE pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 5% EC 50 g ha^{-1} at 20, 40, 60 DAS	34.12	35.02	36.99	42.20
W_2-Pyrithiobac sodium 10% EC 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS as early PoE fb glyphosate 71% SG 2.13 kg ha^{-1} at 45 DAS	32.24	32.24	38.20	42.72
W_3-Pendimethalin 1.0 kg ha^{-1} as PE fb HW at 20 and 45 DAS	33.88	34.4	37.64	41.77
W_4-Unweeded control	28.93	33.58	32.82	39.38
S. Em±	0.98	1.02	0.44	0.76
CD (P=0.05)	2.87	2.97	1.27	2.23
Interaction (D X W)				
S. Em±	1.97	2.04	0.894	1.53
CD (P=0.05)	NS	NS	NS	NS

Table.7 Phenology of Bt cotton under varied plant densities and Weed management practices *kharif*, 2015

Treatment	Days to first square formatoin	Days to first flower open	Days to first boll open	Earli-ness index
Plant densities (D)				
D_1-60 cm×30 cm (55,555)	35	52	106	46.31
D_2-60 cm×15 cm (1,11,111)	37	52	106	56.94
D_3-60 cm×15 cm (1,11,111 Paired row- 45 cm × 75 cm)	37	51	108	51.39
D_4-45 cm×15 cm (1,48,148)	38	51	113	39.65
S. Em±	0.17	0.4	0.4	4.26
CD (P=0.05)	0.5	NS	1.1	12.38
Weed Management Practices (W)				
W_1-Pendimethalin 30% EC 1.0 kg ha^{-1} as PE fb PoE pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 5% EC 50 g ha^{-1} at 20, 40, 60 DAS	36	51	106	63.09
W_2-Pyrithiobac sodium 10% EC 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS as early PoE fb glyphosate 71% SG 2.13 kg ha^{-1} at 45 DAS	36	52	106	53.73
W_3-Pendimethalin 1.0 kg ha^{-1} as PE fb HW at 20 and 45 DAS	36	51	105	52.51
W_4-Unweeded control	38	53	116	24.95
S. Em±	0.17	0.4	0.4	4.26
CD (P=0.05)	0.5	1.0	1.1	12.38
Interaction (D X W)				
S. Em±	0.34	0.73	0.76	8.53
CD (P=0.05)	1.0	NS	NS	24.76

Table.7a Interaction effect of plant densities and weed management practices on earliness index in Bt cotton *kharif*-2015

Earliness index					
D/W	W_1	W_2	W_3	W_4	Mean
D_1	52.94	40.98	48.31	43.03	46.31
D_2	60.93	75.09	64.80	26.96	56.95
D_3	88.01	59.78	48.58	9.19	51.39
D_4	50.51	39.06	48.38	20.65	39.65
Mean	63.10	53.73	52.52	24.96	
S. Em±	8.53				
CD (P=0.05)	24.76				

However, at 90 DAS and 120 DAS significantly more monopodia plant^{-1} was noticed with pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) and was on par with 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3) and early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) treatments. Significantly the lower number of monopodia plant^{-1} was recorded with unweeded control (W_4) treatment.

Interaction effect

Interaction effect of plant densities and weed management practices showed significant influence on number of monopodial branches plant^{-1} of Bt cotton at 120 DAS stage only (Table 4a).

Plant density of 55,555 plants ha^{-1} (D_1) and 1,11,111 plants ha^{-1} (D_2) normal planting along with application of either pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) or early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) or pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3) showed significantly more and on par number of monopodial branches plant^{-1}.

These were followed by 1, 11,111 plants ha^{-1} (D_3) paired row planting with all weed management practices. However, plant density of 1,48,148 plants ha^{-1} (D_4) showed only increased number with weed management practice, pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1). Significantly less number of monopodial branches plant^{-1} was recorded with unweeded control (W_4) at all levels of plant densities.

Height to node ratio

Effect of plant densities

Plant density did not show any significant influence on height to node ratio at 90, 120 DAS and at final harvest stage (Table 5). But, at 30 DAS significantly higher height to node ratio was observed with 1,48,148 plants ha^{-1} (D_4) and was on par with 1,11,111 plants ha^{-1} (D_3) paired row planting and 1,11,111 plants ha^{-1} (D_2) normal planting, significantly lower height to node ratio was observed with 55,555 plants ha^{-1} (D_1). However, at 60 DAS more

height to node ratio was noticed with 1,11,111 plants ha^{-1} (D_2) normal planting and was on par with 55,555 plants ha^{-1} (D_1) and 1,11,111 plants ha^{-1} (D_3) paired row planting, in turn lower height to node ratio observed with 1,48,148 plants ha^{-1} (D_4) treatment. The increased height to node ratio in these treatments might be due to increased plant height at 60 DAS with low plant densities. But at later stages increased plant height and reduced node number increased the height to node ratio at non-significant level.

The enhanced height to node ratio at closer spacings might be due to higher inter plant competition at higher plant populations (Jonathan *et al.,* 2006). The present results were similar to observations of Siebert and Stewart (2006).

Effect of weed management practices

Weed management practices did not show any significant influence on height to node ratio at 90, 120 and at final harvest, but at 30 DAS significantly more height to node ratio was recorded with pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) and was on par with unweeded control (W_4) and pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3) treatments and were significantly superior over early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2). But, at 60 DAS significantly more height to node ratio was recorded with early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) and was significantly superior over rest of other treatments, this was followed by pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) and pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3). These were on par with each other and significantly superior over unweeded control (W_4) treatment.

Interaction effect

Interaction effect of plant densities and weed management practices did not show any significant influence on height to node ratio of Bt cotton at all the crop growth stages.

SPAD value

Effect of plant densities

Plant density did not show any variation in chlorophyll meter value at 60 DAS, 90 DAS and at final harvest stage (Table 6). But at 120 DAS siginicantly higher SPAD value was recorded with 55,555 (D_1) plants ha^{-1} and was followed by 1,11,111 (D_2) plants ha^{-1} normal planting, 1,11,111 (D_3) plants ha^{-1} paired row and 1,48,148 plants ha^{-1} (D_4) and were on par with each other.

Effect of weed management practices

Weed management practices showed significant difference in SPAD values at different growth stages. At 60 and 90 DAS significantly more SPAD value or chlorophyll meter value recorded with pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) and was on par with pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3) and early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2). But, at 120 DAS and final harvest significantly higher SPAD meter values noticed with early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS fb directed spray of glyphosate ammonium salt

2.13 kg ha^{-1} at 45 DAS (W_2) and was on par with pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3) and pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1). The lowest spad values at all the growth stages were recorded with unweeded control (W_4) treatment. This might be due to presence of more weeds.

Interaction effect

Plant densities and weed management practices did not show any significant influence on SPAD reading value of Bt cotton at 60 DAS, 90 DAS and 120 DAS.

Phenology

Days to first square initiation

Effect of plant densities

Early square initiation was observed with 55,555 plants ha^{-1} (D_1), which was significantly superior over rest of the plant densities and was followed by plant density of 1,11,111 plants ha^{-1} (D_2) normal planting, in turn this was on par with 1,11,111 plants ha^{-1} (D_3) paired row planting. Significantly more number of days took to attain square initiation with 1, 48,148 plants ha^{-1} (D_4) (Table 7).

Number of days from planting to first floral bud initiation (squaring) were significantly decreased by narrow row spacing might be due to increased inter plant competition (Munir *et al.,* 2015). These results substantiated the findings of Bednarz *et al.,* (2000) and Mygdakos *et al.,* (2004), who reported that the earliness (early squaring or flowering) increased when row spacing decreased.

Effect of weed management practices

Weed management practices showed significant influence on square initiation. Significantly lesser number of days taken to attain first square with pre emergence application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1) and was on par with pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3) and early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb directed spray glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2), however, unweeded control (W_4) treatment taken more number of days to attain first square. This was due to presence of weeds along the cotton crop might have resulted in delay in square initiation due to reduced availability of resources to cotton crop.

Interaction effect

Significantly early square initiation was observed with population density of 55,555 plants ha^{-1} (D_1) along with pre emergence application pendimethalin 1.0 kg ha^{-1} fb PoE application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1), early PoE application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS fb glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) and pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3), and these were followed by population density of 1,11,111 plants ha^{-1} normal planting and paired row planting along with pre emergence application pendimethalin 1.0 kg ha^{-1} fb PoE application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS (W_1), early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2) and pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS (W_3). whereas plant density of 1,48,148 plants ha^{-1} along with these weed management practices taken more number of days to attain the first square initiation. At all the plant densities unweeded control (W_4) has taken more number of days to get the first square initiation.

References

Ali, H., Abid, S.S., Ahmad, S., Sarwar, N., Arooj, M., Mahmood, A and Shahzad, A.N. 2013. Impact of integrated weed management on flat-sown cotton (*Gossypium hirsutum* L.). *The Journal of Animal and Plant Sciences*. 23 (4): 1185-1192.

Anonymous, 2016. http://cotcorp.gov.in

Bednarz, C.W., Bridges, D.C and Brown, S.M. 2000. Analysis of cotton yield stability across population densities. *Agronomy Journal*. 92: 128-135.

Bhalerao, P.D., Patil, P.U., Ghatol, P.U and Gawande, P.P. 2010. Effect of spacing and fertilizer levels on seed cotton yield under rainfed condition. *Indian Journal of Agriculture Research.* 44 (10): 74-76.

Brar, S., R.J.S. Thindand L.S.Brar,Integrated weed control in upland cotton (*Gossypiumhirsutum* L.). *Indian J. Weed Sci.*, 27(3&4): 138-143.1995.

Devraj, Bhattoo, M.S., Duhan, B.S., Kumari, P and Jain, P.P. 2011. Effect of geometry and fertilizer levels on seed cotton yield and nutrient uptake of Bt cotton under irrigated conditions. *Journal of Cotton Research and Deelopment.* 25 (2):176-180.

Dhillon, G.S., Chabra, K.L and Punia, S.S. 2006. Effect of crop geometry and integrated nutrient management on fibre quality and nutrient uptake by cotton crop. *Journal of Cotton Research and Development.* 20 (2): 221-223.

Hiremath, R., Gurappa, S.Y., Basavaraj, M.C, Ayyanna, D.S., Vidyavathi, G.Y., Rao, B and Koppolkar, G. 2013. Efficacy of chemical weed management in Bt cotton. *Acta Biological Indica*. 2 (2): 425-429.

Jain, S.C., 1982. Nutrient competition and weed control in cotton. *Journal of the Indian society for cotton improvement*. 7: 25-30.

Jalis, A., and Shah, M.L. 1982. Weed control in cotton resume. *The Pak Cottons*. 26 (3):141-148.

Jonathan, D., Siebert and Alexander, M., Stewart. 2006. Influence of plant density on cotton response to mepiquat chloride application. *Agronomy Journal*. 98: 1634-1639.

Munir, M.K., Tahir, M., Saleem, M.F and Yaseen, M. 2015. Growth, yield and earliness response of cotton to row spacing and nitrogen management. *The Journal of Animal & Plant Sciences.* 25 (3): 729-738.

Mygdakos, E., Avgoulas, C., Adamidis, K and Ekonomou, G. 2004. Cotton cultivation on narrow rows as an alternative culture method: Production and economics. *Journal of Food, Agriculture and Environment*. 2: 198-201.

Pawar, A.K., B.M. Patil., A.P. Karunakar and Satao, R.N.2000. Effect of pre and post emergence herbicides on weed control and yield of cotton. *Pestology*. 24: 13-17.

Siebert, J.D., and Stewart, A.M. 2006. Influence of plant density on cotton response to mepiquat chloride application. *Agronomy Journal*. 98: 1634-1639.

Venugopalan, M.V., Sankaranarayanan, K., Blaise, D., Nalayini, P., prahraj, C. S. and Gangaiah, B. 2009. Bt cotton (Gossypium sp.) in India and its agronomic requirements A review. *Indian J. of Agronomy*. 54 (4): 343-360.

Wang, G., Assimwe, R.K and Andrade, P. 2011. Growth and yield response to plant population of two cotton varieties with different growth habits. Arizona cotton report (161). Pp. 6-11.

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